The clam is *Tapes staminea* Conrad, and while this was the most abundant species, other bivalves, as *Cardium nuttalli*, Conrad, and some species of *Macoma* were present in fair numbers. It was however only on the *Tapes* that any *Isapis* were found. On these they adhered quite closely, so that the digging, and even a rinse did not appear to dislodge them.

While it was seldom that I found more than two or three *Isapis* on one shell, and usually only one, in several cases, I took a *Tapes* with a whole lot of small fry massed together, perhaps as many as 20 fine shells, and others had what looked like the spawn. Their position on the *Tapes* was always close to the lips, and I think nearly always in the depression close to the beaks. Besides this species I took more rarely on the *Tapes*, a species of *Odostomia* (*Ivalea*); it also occurred on the *Cardium*. Dr. Bartsch says of it, "too young to permit of positive specific identification." This *Ivalea* may have been more abundant than I found it, being of such small size, and as I discovered very easily rubbed off. It appears to me not unlikely that *Isapis fenestrata*, may have similar habits, and that therefore, where it has been taken dead and rarely, it may prove quite as plentiful as *I. obtusa* has in this case. I should say that in our Northern waters, *obtusa* must be very local, or it would surely have been turned up "dead" long before this, by the collectors, who have done considerable collecting and dredging on our British Columbia coasts.

Included in this sending to Dr. Bartsch was *Odostomia* (*Amaura*) *talpa* Dall & Bartsch, which appears to be new to our B. C. Lists, and which species I gathered in fair numbers in this same spot, at extreme low tide, all dead and containing hermit crabs.

THE ANATOMICAL STRUCTURE OF CERTAIN EXOTIC NAIADES COMPARED WITH THAT OF THE NORTH AMERICAN FORMS.

BY DR. A. E. ORTMANN.

(*Continued from p. 108.*)

Gills long and narrow, the inner the wider. Edge of inner gill with the usual longitudinal furrow, which is missing on the outer gill. Outer gill gradually narrowing anteriorly, its anterior end situated at the highest point of the mantle-attachment line. Inner

gill hardly narrower anteriorly, its anterior insertion broad, occupying the whole space between the anterior end of the outer gill and the posterior end of the palpi (the ascending part of the mantle-attachment line); the inner gill is in direct continuation of and in contact with the inner palpus, in fact the base of the latter is actually connected with the inner gill for a short distance.

Outer lamina of outer gill entirely connected with the mantle; inner lamina of inner gill entirely connected with abdominal sac; posteriorly to the foot the two inner laminæ are connected with each other as usual, thus forming the diaphragm, but the four gills do not extend as far back as to the posterior mantle margin, and the posterior part of the diaphragm is formed by the union of the two mantle edges, which form a solid bridge (*d* in the figure 6 on pl. ii). The latter is 4 mm. long, while the gill part of the diaphragm is 16 mm. long (in a specimen of which the total length of the soft parts is about 82 mm.

A male not being present, the structure of the gills cannot be made out, but it very likely is identical with the structure of the outer gill in the female.

In the female the inner gill serves as marsupium, but only the inner portion of it, about one-fourth of its length at the anterior end and a little less than one-fourth at the posterior end, being non-marsupial. The swelling of the marsupium during the breeding season is not very great, and its edge remains sharp.

In the non-marsupial outer gill a development of septa and water tubes is barely indicated, in fact there are none, as compared with North American forms. There are rather slight, indistinct and distant ridges running on the inner side of the laminæ from base to edge, parallel to the direction of the filaments, but these ridges are not connected with each other across the interlamellar cavity, except at certain points by more or less cylindrical connections. The latter are more distinct and frequent and stronger near the base of the gill; they are rather scarce and slight in the middle of the gill, and again better developed toward the edge, where they sometimes are slighly elongated and like septa. But there are no continuous septa whatever, and thus the interlamellar space is not divided into water tubes.

In the marsupial part of the inner gill the connections between the two laminæ are more crowded and numerous and become more

regular, but they do not form complete septa; an arrangement into septa is indicated in so far as the connections stand in rows, but the septa remain, so to speak, perforated, the holes in them being about as long or slightly longer than the connections, and in the most central part of the gill an alternating arrangement of adjacent rows is noticed. Thus there are no distinct ovisacs, the latter forming rather a network of communicating tubes. In the non-marsupial anterior and posterior end of the inner gills the structure is similar to the outer gill. The interlamellar connections of the marsupium are rather thick, with thick epithelium, and when the marsupium is charged they stretch out considerably.

In the gravid female at hand the marsupium was filled with eggs in various stages of development, which were rather free from each other, not forming placentæ. No fully developed larvæ were seen.

The following four characters of *Hyria* are of prime importance: 1. The closing of the anal opening above without forming a supra-anal. 2. The separation of the anal from the branchial opening by a solid bridge, formed by the union of the mantle edges (diaphragm). 3. The contiguity of the inner gill with the inner palpus. 4. The location of the marsupium in the inner gill alone. None of these characters is found in any North American shell, but all four are observed in *Spatha*. In addition, the palpi are more like *Spatha* in their general shape, although they differ somewhat.

The most important difference from *Spatha* consists of the structure of the gills, chiefly the marsupium. Septa and water tubes are very rudimentary in the non-marsupial gill, and the interrupted septa and communicating water tubes of the marsupium are quite unique. In this respect *Hyria* may be compared only with *Margaritana*, but in the latter genus the interlamellar connections are quite irregular, and do not show the slightest arrangement in rows parallel to the filaments. Although there is a certain analogy to *Margaritana* there is surely no homology.

Another important difference is the restriction of the marsupium to a part of the gill, while the complete connection of the inner lamina of the inner gill with the abdominal sac is apparently of minor value.

The conclusion is that *Hyria* undoubtedly stands nearer to *Spatha* than to any of the North American genera, and that it is as widely

remote from the so-called "*Hyriinæ*" of Asia, at least from the two investigated genera, *Parreysia* and *Lamellidens*.

If *Spatha* is to be placed in a family different from the *Unionidæ*, *Hyria* has to go out of the *Unionidæ* also, and has to remain with *Spatha*. Yet the differences from *Spatha* are such that possibly the separation into two subfamilies would be advisable. This suggestion will be supported by the following observations:

Tetraplodon undosus (v. Mart.).[1]

This species was collected by Mr. J. D. Haseman in the Rio Tiété, 25 miles above Itapura, State of São Paulo, Brazil, on "silty river banks," Sept. 27, '08. There are several lots at hand, and the one more closely investigated consists of four specimens with the soft parts, among them males and sterile females.

The structure of the soft parts of this species is essentially identical with that of *Hyria*, but I note the following differences (see pl. VI, fig. 7, and pl. VII, fig. 7):

Branchial opening closed in front by the firm union of the inner mantle edges (*x* in fig. 7, pl. ii). This connection is rather short, and restricted to the edge, and does not continue inward. It is easily torn by rough handling. Further in front the mantle edges are smooth and unconnected.

The palpi are rather wide and slightly produced posteriorly, with a blunt point, thus becoming almost semilunar, but not falcate; their posterior edge is connected for about one-third.

The anterior end of the inner gill is in contact with the posterior end of the inner palpus, but not connected with it.

The gill structure in the male is in both gills the same as described for the outer gill in *Hyria*. In the sterile female (pl. VII, fig. 7) it is as in the female of *Hyria*. Also here the marsupial part does not occupy the whole gill, but only a portion in the middle, leaving a larger portion free anteriorly and a smaller portion posteriorly.

Thus *Tetraplodon* is distinguished from *Hyria* not only by the shape of the shell, but also by some differences in the soft parts: the chief is the connection of the mantle edges in front of the branchial opening. Whether this is found in all species remains to be seen.

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[1] I do not understand why Simpson (Pr. U. S. Mus. 22, '00, p. 866) places this species with *Castalina* v. Ihering, since it is undoubtedly a *Castalia* (= *Tetraplodon*); von Ihering himself placed this species correctly.

However, it is present in *Tetraplodon ambiguus* (Sow.). I have examined a young specimen (male) from Santarem, collected by J. D. Haseman, together with *Hyria corrugata*. As far as could be made out it agrees also in the rest of the structure.

Possibly also the shape of the palpi are important for the distinction of these two genera.

Nevertheless, *Tetraplodon* agrees with *Hyria* in the essential characters of the soft parts, and it has the same affinity with the African *Spatha*, *Hyria* has, and it differs from *Spatha* in the same features as *Hyria*, namely, in the structure of the gills and the marsupium.

I may add, that I have also examined, superficially, a species of the genus *Castalina*, and several species of *Diplodon* from South America. In all these, the palpi, the attachment of the inner gill, the diaphragm, the anal opening and the location of the marsupium, are of the same type, as in *Hyria*, *Tetraplodon*, and *Spatha*, and the structure of the marsupium is like that of *Hyria* and *Tetraplodon*. The mantle edges are not connected in front of the branchial opening.[1]

Thus it is clear that a number of South American *Unionidæ*, subfam. *Hyriinæ*, group with the African *Spatha*, which stands, in Simpson's system, in a different family, *Mutelidæ*, distinguished, according to Simpson, by the taxodont hinge teeth, and by the embryo, which is a *lasidium* and not a *glochidium*, as in the *Unionidæ*.

So far I have seen fully developed embryos only in a species of *Diplodon*.[2] Here they are *glochidia*, of peculiar shape, not almost equilateral as in the North American forms, but distinctly inequilateral, with a low anterior and a high posterior extremity, which ends in a point at the postbasal angle.[3]

The embryo of *Spatha* is apparently unknown, in fact, the larval form, called *lasidium*, is known only in two species of the genus *Glabaris*,[4] and it is only by inference, on account of the supposed

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[1] According to v. Ihering (Zool. Anz. 14, '91, p. 477 ff.), this connection is variable in *Castalina*, present or absent.

[2] Belonging to the *delodontus* group, and allied to *æthiops* (Lea) and *wagnerianus* Simps.; it is from Rio Iguassu, Parana, Brazil.

[3] Much more oblique than the glochidium of *Diplodon peculiaris* (Lea), figured by Lea (Observ. XII, pl. 34, fig. 80).

[4] See v. Ihering, Zool. Anz. 14, '91, pp. 480–482.

similarity of the anatomy and shell, that a *lasidium* is attributed to all *Mutelidæ*. Nevertheless, it is quite probable, that *Spatha* has also a *lasidium*, for the South American genus *Glabaris* is still more like *Spatha* in its structure, than is *Hyria* and its allied forms. I have investigated a number of specimens of *Glabaris*, *Fossula*, and *Monocondylæa*, and they all had the essential structure of *Spatha:* a firm bridge separating anal and branchial opening; the same attachment of the anterior end of the inner gill; the marsupium practically occupying the whole length of the inner gill; and the gills with well-developed water-tubes and heavy, continuous septa. The differences from *Spatha* are found in the connection of the inner lamina of the inner gills with the abdominal sac, which I consider unimportant; in the shape of the palpi, which are rather variable, but always more or less rounded and broad, not falcate; and in the anal opening, which in *Glabaris*, *Fossula*, and *Monocondylæa*, is always entirely open and closed nowhere. The most interesting fact in the three latter genera is the similarity of the structure of the water-tubes and septa of the gills to that of *Spatha*. If we may say that *Hyria*, *Tetraplodon* and *Diplodon* ought to stand in the same family with *Spatha*, we must also admit *Glabaris*, *Fossula* and *Monocondylæa*, and the latter are even more closely allied to *Spatha* than the former. Thus it would be suggested that we have here one family, possibly to be called *Mutelidæ*, which is divided chiefly by the character of the gill structure and marsupium, but also by shell characters (hinge),[1] into two subfamilies, the one (*Hyriinæ*) including at least three South American genera, the other including three South American and one African genus. For the latter possibly the name *Mutelinæ* might be used, but this depends on our knowledge of the soft parts of the type-genus *Mutela*.

The conclusions to be drawn from the present investigations are:

1. Of the Asiatic so-called *Hyriinæ* at least *Parreysia* and *Lamellidens* are to be removed, and are to be associated with the North American genera *Quadrula*, *Rotundaria*, *Pleurobema* and *Unio* in the subfamily *Unioninæ* of the family *Unionidæ*.

2. The African *Mutelid* genus *Spatha* and the South American

[1] Also the larva (lasidium) might furnish a differential character. I have seen several gravid specimens of *Glabaris*, but they had only eggs, and no fully developed larvæ.

Mutelid genera *Glabaris*, *Fossula*, *Monocondylæa*, and further, the South American *Hyriinæ : Hyria*, *Tetraplodon* and *Diplodon*, group together, and their differences from the North American and Asiatic forms discussed above are such that we are fully justified in placing them in a separate family, whatever the name of the latter may be.

3. Within this Afro-American family we may distinguish two types, differing in very important characters, which might properly be subfamilies (*Hyriinæ* and *Mutelinæ*).

4. The systematic affinity of African and South American genera, already pointed out by v. Ihering, is much more striking, and much better supported, than before, and it is of the most important value for zoögeographical questions, namely, for the theory of an old connection between these continents (Archhelensis theory of v. Ihering).

5. The natural system of the *Naiades* expresses a tendency of development and specialization of three chief anatomical characters, which in turn are connected with certain functions. These are: (a) the separation of the original simple branchial chamber into two chambers, branchial and suprabranchial, by the diaphragm; (b) the restriction of the branchial and anal openings of the mantle edge to defined parts of the latter, with a tendency to form siphons; (c) the development of the gills into organs for carrying the eggs and larvæ (marsupium), and the specialization and adaptation of the gill structure for this purpose.

(a) In the development of the diaphragm three types are distinguishable. The most primitive stage is represented in *Margaritana*, where the diaphragm is formed by the growing together of the inner laminæ of the inner gills of the two sides of the body, and the fusion of the outer laminæ of the outer gills with the mantle. But here the diaphragm is yet incomplete, in so far as the outer laminæ of the outer gills remain free at the posterior end, and are not connected with the mantle to its posterior margin.

(*To be concluded.*)

NOTES.

Dr. W. H. Dall was elected president of the American Palaeontological Society at its recent Pittsburg meeting.